Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Spectrum Policy Task Force	)	ET Docket No. 02-135
Seeks Public Comment on Issues	)	
Related to the Commission's	)	
Spectrum Policies	)	

COMMENTS OF FLARION TECHNOLOGIES, INC.

Flarion Technologies, Inc. ("Flarion") respectfully submits these Comments in response to the request for public comment from the Commission's Spectrum Policy Task Force ("Task Force") on issues relating to the Commission's spectrum policies.[1] In particular, the Task Force has sought comment and information on how to promote and measure spectral efficiency (item numbers 17 through 20 in the *Public Notice*).[2] Flarion's detailed responses to the Task Force's inquiries on spectral efficiency inquiries are set forth in Attachment A to these Comments. Question numbers correspond to the numbering used in the Public Notice dated June 6, 2002 (DA 02-1311).

Flarion is developing and commercializing a new wireless data access technology known as flash-OFDM (Orthogonal Frequency Division Multiplexing) that will provide mobile network operators with breakthrough speed, reliability, and cost effectiveness. This innovative technology will allow mobile users of devices such as PDAs, handheld PCs, laptops, and smart phones to access the Internet, voice over IP,

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[1] *See Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policies*, Public Notice, DA 02-1211, ET Docket No. 02-135 (rel. June 6, 2002) (the "*Public Notice*").

[2] *Public Notice* at 5.

and other multimedia services at speeds previously available only over broadband connections such as DSL and cable.

As explained further in Attachment A hereto, flash-OFDM technology is a very spectrally efficient, low cost technology that will provide end users with broadband mobile data communications using existing Internet protocols and applications. As the demand for wireless data services grows, the Commission should encourage more spectrally efficient technologies, such as flash-OFDM, by removing barriers to deployment and by adopting common standards to measure spectral efficiency quantitatively and to compare the relative performance of various wireless systems as experienced by typical end users.

Respectfully submitted,

FLARION TECHNOLOGIES, INC.

By: ______________________
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ATTACHMENT A

RESPONSES OF FLARION TECHNOLOGIES, INC. TO SPECTRUM POLICY TASK FORCE'S INQUIRIES ON SPECTRAL EFFICIENCY

QUESTION 17: What mechanisms or policies might be considered as a means of promoting a proper level of spectral efficiency either through regulatory mandates or economic incentives? Are there mechanisms that other countries use that should be applied in the United States as well?

FLARION RESPONSE: Commercial wireless operators offer voice/data services in a competitive market and, therefore, already have enough economic incentives to deploy cost effective and spectrally efficient technologies without further regulatory mandates. Other spectrum users, have very few or no competitors, and, therefore, they have little incentive to migrate to more spectrally-efficient technologies. Such spectrum users should be encouraged to do so, principally by creating economic incentives to do so and, if economic incentives fail, by imposing regulatory mandates.

QUESTION 18: Do any existing Commission rules inhibit efficient use of the spectrum? If so, how should they be changed?

FLARION RESPONSE: Certain of the Commission's rules seem to have loopholes that permit warehousing of spectrum by entities that have no intention of using the frequencies to provide service. The Commission should impose tougher regulations and build-out requirements in order to prevent such spectrum warehousing and to ensure that the spectrum is used for its intended purpose expeditiously.

QUESTION 19: What new technologies exist that, if deployed, could improve spectral efficiencies and utilization? What are the barriers to their deployment?

FLARION RESPONSE: The demand for wireless voice services has grown steadily over the years and continues to increase. While still a relatively small percentage of overall wireless traffic at present, wireless data services also are increasing proportionately in demand and use.. The future may see this shift to wireless data services accelerate, reflecting the popularity and growth of the Internet, once systems optimized for the unique requirements of data traffic are developed and deployed. A number of recent technological developments can lead to very spectrally efficient wireless data systems designed to provide end users with broadband mobile connectivity to the Internet. These systems must satisfy a number of design objectives, including:

- Spectrally efficient, high capacity physical layer
- Packet switched air interface
- Quality of service ("QOS") aware media access control ("MAC") layer
- Support for interactive data application including voice
- Efficient operation using all existing Internet protocols (TCP/IP, etc.)
- Low cost

The migration from voice to data will change the meaning of spectral efficiency and the way it needs to be measured. Voice services have been appropriately characterized over time as requiring low bandwidth and a relatively stable 50% duty cycle model. This enables a simple circuit switched architecture and capacity engineering using the common Erlang tables for network dimensioning.

Data services, on the other hand, are made up of numerous and varied applications, which typically are used over the public Internet or corporate networks and LANs. Generally, there are many users simultaneously sharing network resources in a sporadic manner. The network traffic demand that results is "bursty" in nature because of the mix of applications, message sizes, throughput needs, and latency sensitivity. Efficiencies are realized through statistical multiplexing achieved by packet switching. The applications and protocols developed to transport data packets assume the high link reliability achieved on wireline networks. Therefore, whereas voice systems reside at the physical layer, wireless data systems also require MAC and link layers to perform adequately. Because of the variability in demand for data services and the inherent difficulty of operating in the wireless environment, it is impractical to expect systems and architectures built for voice communications to be equally efficient for data communications or to be capable of delivering an end user experience that people are accustomed to getting over wireline connections.

While voice systems are optimized at the physical layer for circuit connections, efficient data systems need to be jointly optimized across the physical, MAC, link and network layers. The physical layer technology that is particularly suitable for this jointly optimized design is OFDM (Orthogonal Frequency Division Multiple access).

At the physical layer, OFDM forms the basis for a higher performance wireless link layer to serve packetized data delivery. OFDM divides a segment of spectrum into a number of frequency tones. Each tone occupies a set amount of bandwidth and is used to send digitally modulated data symbols. The duration of a symbol is related to the frequency of a tone such that the modulated tones are mutually orthogonal, and do not create intercarrier interference. Additionally, the symbols can be cyclically extended in such a way as to prevent intersymbol interference in the presence of multipath delay spread. Tones can be allocated to multiple users through a time and frequency multiplexing scheme in order to maximize the capacity of the system over the aggregate of the users served within the cell. If the multiplex scheme is randomized between adjacent cells, OFDM can provide good interference averaging properties allowing for a frequency reuse of 1 and maximum geographic coverage with minimum spectrum requirements.

Because OFDM provides for orthogonal signaling to multiple users, even in the presence of multipath, it allows for the efficient allocation of spectrum resources among users. Users can be assigned power and modulation density based strictly upon the channel conditions as experienced by that particular user. Thus users in the cell interior, who see high signal to noise ratios, can be assigned high density modulation over a large bandwidth, have high peak data rates, and consume less time resources for a given level of service. A user at the fringe of the cell may be assigned a large proportion of the power over a small bandwidth and still receive an acceptable level of service without consuming excessive time and bandwidth resources.

Another capability of OFDM is the fine quantization of traffic resources. A single unit of transmission in an OFDM system is a single tone in a single symbol. This represents a very small number of bits and provides an efficient mechanism for the delivery of low rate control channels. This, in turn, allows the MAC layer to signal information such as channel power control, instantaneous channel capacity, and channel coding and assignment, with very low overhead.

An OFDM physical layer enables sophisticated resource scheduling schemes that can be used to optimize the instantaneous channel capacity within the system. Such scheduling scheme must take into account the estimated instantaneous channel capacity for each user, the user's throughput needs. and the physical layer resources available. Thus the scheduler can assign bandwidth resources that maximize the possible system throughput at that time. Additionally, since a wireless channel is a dynamic environment, the scheduling algorithm must have channel estimate information with low latency and schedule over short time durations in order to insure that the channel capacity is accurately estimated and can be achieved.

Beyond physical layer advantages, OFDM technology can lead to an advanced MAC layer to support existing data networking protocols, such as TCP/IP, and applications in a transparent manner. To accomplish this, the MAC layer must support delivery with the reliability expected from a wireline network. Reliability can be ensured through a link layer featuring a fast ARQ loop to provide low latency retransmission of frames received in error, which is an unavoidable reality of wireless communications. This allows end users use the applications they presently use in the manner to which they are accustomed. The MAC design is critical to the efficient use of scarce wireless resources and is responsible for the system's ability to provide low latency and Quality of Service ("QOS") to a large set of active users. It is not enough to have high spectral efficiency at the physical layer if the overhead required to allocate resources to and control the system takes a significant fraction of the physical layer bits, or if there is a large amount of latency added. The ultimate measure of spectral efficiency, therefore, should be related to the "goodput" of the system, which is simply the number of user payload bits successfully transferred by the system.

A MAC design should leverage OFDM by enabling virtually overhead free and low bit rate dedicated control channels to be given to a large number of users within a cell. The ability to support many low bit rate control channels is highly advantageous for data systems for the following reasons:

- Efficient admission control so that channel resources can be quickly allocated and shared among multiple users.
- The support for QOS is dependent upon the system's ability to distinguish a user's priority profile in real time. Multiple dedicated control channels enable a system to virtually eliminate the use of contention based access employed in other systems. This enables the system to almost instantly see a user's requests for resources along with the corresponding application class and user priority, thereby allowing the support of full QOS discipline.
- Acknowledgements (ACK, NAK) of received packets, which are required for ARQ, can be sent very frequently while using a minimum of resources. OFDM is capable of sending a single bit, with no overhead, to acknowledge the receipt of a packet

A system that supports the differentiation of delivery requirements based on data content is essential to support multiple services within a single system. Different applications, such a voice or web surfing, may have very different delivery requirements. In order for a single system to support both applications efficiently, the system must be able to differentiate between the services and deliver data in a manner appropriate for the service. For example, voice services are relative low continuous bandwidth but have very tight latency and jitter constraints, whereas web surfing may have high burst bandwidth requirements but is relatively immune to latency and jitter variation. A system optimized to either one of these applications, but not service aware, would provide poor efficiency for the other.

The flash-OFDM system developed by Flarion Technologies is as example of a spectrally efficient system designed, from the ground up, to provide broadband mobile data communications to end users using existing Internet protocols (e.g., TCP/IP) and applications.

Flarion has developed economic models demonstrating that a flash-OFDM system deployed nationwide, covering more than 150 million Pops, can serve more than 10 million users, consuming 200 Mbytes of data per month, with only a single 1.25 MHz channel and base stations collocated at existing cell sites (without requiring the construction of additional cell sites). Based on these models, the cost to deliver each bit of data would be less than 1/10 the cost required to use systems that are deployed today, with 1/3 the amount of spectrum being used.

The barriers to the adoption of the flash-OFDM system are due to the ubiquitous deployment of 2G systems and the 2G system operators' desire for backward compatibility. By relying on backward compatibility, the spectral efficiencies and user benefits of new systems like flash-OFDM may take longer to materialize. Ultimately, the deployment of 2G derivative systems may not provide sufficient performance and cost benefit to end users to enable a mass market to develop quickly. The desire to protect the sunk cost investments already made in such systems, act as a powerful short-term obstacle to the adoption of new architectures and systems. Measures providing incentives for the adoption of more capable technologies would be go a long way towards helping operators evaluate the business plans and associated risks involved in deploying new systems. Adoption of common metrics used to evaluate the efficiency of data systems, as discussed in Flarion's response to Question 20 below, also would help operators make decisions that optimize spectral-efficiency.

QUESTION 20: Should the Commission consider ways to quantify or benchmark spectral efficiency in a way that permits fair and meaningful comparisons of different radio services, and if so, how would such comparisons be used in formulating spectrum policy?

FLARION RESPONSE: Yes, the Commission should develop common standards to measure both spectral efficiency and relative system performance as experienced by typical end users. This would facilitate the comparison of different systems according to standardized methodologies developed by an impartial and reliable source. There has been a tremendous amount of "blue sky" regarding the performance of 3G systems, much of which has had to be withdrawn or restated as these systems come closer to deployment. Reliable and objective assessments of system performance, with well defined traffic models for relative comparisons, would help the Commission in its long-term planning to determine the spectrum needs of future services.

<u>QUESTION 20(a)</u>: How could the Commission define and quantify spectral efficiency?

> **<u>FLARION RESPONSE</u>:** Spectral efficiency should be defined as the amount of end user payload data (*i.e.*, "goodput") that can be transferred in a loaded system on a sustainable basis. While this can be defined simply as the bps/Hz of spectrum used, it is also important that it reflect real world characteristics of end user experience using the protocols and application of the Internet. It does little good if a system has high spectral efficiency (*i.e.*, throughput), but achieves this at the expense of important dimensions of user satisfaction, such as delay or accessibility. It must also be defined on the basis of sustainable capacity or throughput and the number of users that can be supported, as these are the factors that operators typically use when evaluating different systems.

<u>QUESTION 20(b)</u>: How could the Commission meaningfully compare efficiencies across different radio services?

> **<u>FLARION RESPONSE</u>:** A common set of assumptions and models applied across radio services must be developed in order to facilitate a meaningful comparison of different technologies and services. These include service definitions, models for traffic among different services, channel models, propagation models, as well as assumptions about network architectures and user behavior and geographic location with respect to cell or other transmission sites and other users for interference purposes. While different services clearly have distinct characteristics, representative models can be constructed to enable comparison. Metrics relevant to each service should be created to reflect user experience and system performance. Overall comparisons of different services can be accomplished by varying the mix of services.

<u>QUESTION 20(c)</u>: Should spectrum efficiency be analyzed subjectively as opposed to quantitatively? If yes, how?

> **<u>FLARION RESPONSE</u>:** Spectrum efficiency should be analyzed in a quantitative manner because using qualitative and subjective metrics alone is not likely to provide reliable measurements that can be applied universally.

<u>QUESTION 20(d)</u>: Intentionally omitted. No response.

<u>QUESTION 20(e)</u>: What data and other information are necessary for the Commission to evaluate spectral efficiency?

<u>FLARION RESPONSE</u>: The evaluation of spectral efficiency ultimately will depend upon the models assumed and how the systems involved are implemented. Models of different technologies would have to be developed using simulation tools. However, these models invariably will capture only the details of the systems, as established in standards, and not in the manufacturers' implementation of those standards.